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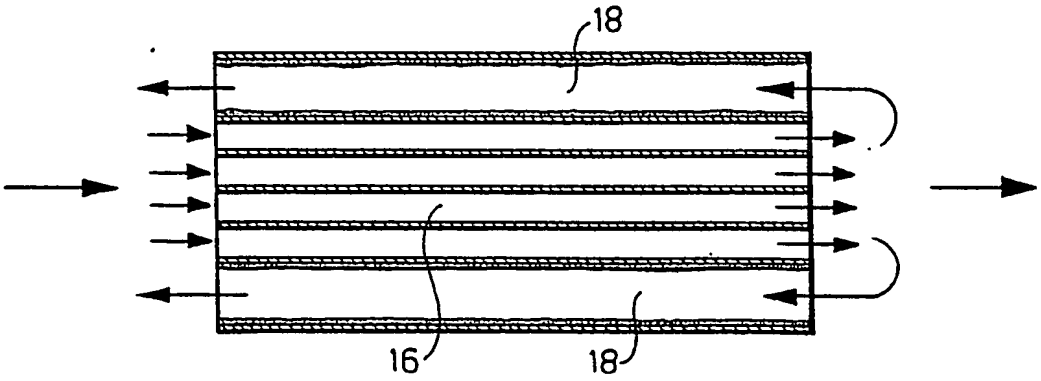

(57) Abstract

Method and apparatus for conditioning of rooms or spaces for cooling of the room air, wherein a contact body (10) is used which is made up of layers and divided into two duct systems (16, 18). The first duct system (16) is passed through by, respectively, a useful air current which is to be cooled and other duct system (18) by a cooling air current. The cooling is effected by evaporation of water into the second duct system (18). The useful air current is taken from the room and the cooling of the same is effected thereby that a part of this air current after its passage through the first duct system (16) is branched off and returned through the second duct system (18) as cooling air current.

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Method and apparatus for cooling of rooms.

The present invention relates to a method and an apparatus for cooling of rooms or spaces, wherein a contact body is used, which body is made up from layers and divided into two systems of ducts, of which one duct system is passed by a useful air current (room air) which is to be cooled, and the other duct system is passed by a cooling air current which achieves the cooling of the firstmentioned air current.

In existent older buildings the rooms are usually ventilated by means of intake air (outside air) which is taken in through windows and discharged through valves into an exhaust air duct. In newer buildings a balanced ventilation is used, wherein both the intake air (outside air) and the exhaust air, i.e. consumed room air, stream in two separate duct systems to or from, respectively, the room.

When in summertime intending to cool the room, the ventilation system must be arranged in another manner than when it is designed for ventilation only. In older buildings it is impossible to cool the intake air in an acceptable manner. In more modern systems of the balanced type such a result can be achieved by installing a refrigerating machine in addition to the central air conditioning system for the intake air. This is, however, not as simple to perform as it sounds, when one is compelled to blow in air having a lower temperature than that of the room in order to keep the temperature of the room on a desired level. It is impossible to blow in as cold air as

possibly required, and normally its temperature is not allowed to be lower than 10-15 C, and then it becomes apparent that the quantity of ventilation air is not sufficient for carrying and delivering the required quantity of cooling medium. This is the substantial impediment to conversion of a usual ventilation plant into a complete air conditioning plant. Hereto is to be added that in a pure ventilation plant the air ducts normally need not to be insulated behind the so-called preheating radiator, i.e. that radiator which heats the air in winter from the temperature of the outside air to serviceable room temperature. If, however, chilliness shall be conveyed with the intake air from the central aggregate, the intake air ducts must be equipped with an insulation.

Therefore, for in summer airconditioning a building, there are generally three possibilities only. The first one is to install central cooling and to dimension the quantities of intake air and exhaust air so as to be sufficient for carrying and delivering the chilliness (a duplication may be involved) and to insulate the intake air duct.

Another possibility is to make use of an induction system, wherein a limited quantity of air is blown under high pressure into a so-called induction apparatus, the same sucking up room air also, the mixture then passing a cooling radiator provided in the induction apparatus.

A third possibility is to install an individual cooling aggregate in each room. This involves that one has to place the condenser in contact with the outside air, whereas the cooling radiator is placed inside the room.

The drawbacks inherent to all these possibilities are that the remodelling of the existing ventilation system or a new installation of the system becomes complicated, costly, often affects the appearance of the locality and results in disturbing noise from fans and compressors and involves an additional load on the electricity supply and, more energy is consumed for the drift of the refrigerating compressor.

Another method of cooling a space is effected with so-called indirect, evaporative cooling, which implies that the exhaust air is caused at first to pass an evaporative cooler where it is cooled, and thereafter a rotating heat exchanger, within which the cooled exhaust air cools the entering intake air.

Even such a plant has disadvantages, when the lower temperature which is reached with the available air quantities is not sufficient for keeping the room at the desired low temperature. Thus, considerably more air is required than the normal quantity of ventilation air for reaching the desired room temperature.

The main object of the present invention is to provide a method and an apparatus for cooling or conditioning of the intake air to a building or space, wherein the drawbacks inherent to the above described, known systems are eliminated.

Another object is to provide such a method and apparatus which is very simple and cheap to install and to operate.

These and other objects of the invention are achieved thereby that the method and the apparatus have been given the characteristic features stated in the subse-

quent claims.

The invention will be described nearer in the following in connection with embodiments of the same shown in the attached drawing.

Fig. 1 shows a preferred embodiment of an apparatus which is used for cooling a room in accordance with the invention.
Fig. 2 shows a horizontal section along the line II-II through the apparatus of Fig. 1.
Fig. 3 shows the flow of the exhaust air in the apparatus of Fig. 1.
Fig. 4 shows a view similar to Fig. 3 through a modified embodiment.
Fig. 5 shows a cross-section through the layer structure of the apparatus according to the invention.
Fig. 6 shows a plate or panel in the apparatus according to Fig. 1.

The contact body 10 shown in Fig. 1 is used as an indirect, evaporative heat exchanger for heat exchange between a useful air flow, which flows substantially horizontally through the contact body and which shall be cooled and supplied to the inclined lower end wall surface 28 shown in Fig. 1. and constituting the inlet to a first duct system in the contact body, and which flows therethrough in the longitudinal direction along said ducts or gaps, which are separated from adjacent ducts or gaps in a second duct system passed through by a cooling air current.

The contact body may be made up from, for example, a plurality of flat plates 11-15, which, as is evident from Fig. 5, are put together with interposed, flange-like stiffening and surface magnifying means, which

in the illustrated embodiment are constituted by corrugated metal sheets or foils 16. The corrugations in the metal sheet or foil 16 constitute the ducts for the useful air which is to be cooled in the contact body, the corrugated sheets or foils 16 being oriented with their corrugations extending in the flow direction of the air. The corrugated foil or sheet 16 thus defines the width of the ducts or gaps in the contact body through which the useful air passes. The corrugations or folds of the sheet or foils 16 must be in good heat conductive contact with the surfaces of the flat plates 11-15. When there are several layers, the crests of the corrugations shall be positioned immediately opposite each other which increases the stability of the body and gives a shorter path for heat conduction.

The plates 11-15 and sheets 16 are of a thin material with good heat conductivity such as metal, e.g. aluminum, and are joined together by heat bonding, gluing or other suitable jointing method. They may, for example, be made as sandwich elements which in themselves are shaped permanent. As will be seen from Fig. 5, a desired number of such elements are joined to each other with an intermediate space determined by spacers 32 (Fig. 6) arranged between them. The spacers thus define the width of the gaps 18 in the second duct system in the contact body, through which the cooling air shall pass.

For achieving the evaporative cooling effect the walls of the gaps 18 are wetted in known manner, for which purpose the surface of the plates or foils 11-15 facing the gaps 18 is provided with a coating denoted 20 of a water absorbing and/or soaking material.

During the passage of the cooling air through the gaps 18 there will be evaporation of water into the cooling air, so that an intensive transference of heat is obtained from the useful air in the first duct system to the cooling air in the ducts 18, thus reducing the temperature of the useful air to a low value. The walls are normally only kept moistened to the extent required for the evaporation. The gaps passed through by the cooling air can be made considerably narrower, due to the evaporative cooling effect, than the gaps passed through by the useful air, which in a simple way is rendered possible by the composed structure according to the invention, wherein the sandwich elements 11-15 and 16 and the gaps (spacers) 18 can be given any desired width (breadth) independently of each other. Due to the evaporative effect the required quantity of cooling air normally is also minor than the quantity of useful air.

The flanges of the stiffening means or corrugated sheets 16, included in the sandwich element 12-16 constitute a large heat transfer surface which is swept over by the passing useful air current.

In the embodiment shown in Fig. 5 the intrinsically stiff panels are made from five flat plates or foils 11-15 with intermediate corrugated sheets or foils 16, but they may of course be made up of only two flat plates or foils 12, 14 with one intermediate sheet or foil 16 or still more flat plates (foils) and corrugated sheets in order to increase the width and/or stiffness of the panel and also the heat transfer surface. The structure with several layers has the advantage that the wet gap can be made wider and will become less sensitive to variations in the gap width. There will also be fewer panels to handle and the panels will be stronger.

According to the invention, the described apparatus 10 is utilized in the following manner. It is installed in the space which is to be conditioned or cooled, and the room air already present is forced by means of a fan 22 which is shown in Fig. 1, to the inlet 28 into the first duct system with the ducts 16. A part, e.g. 10-50%, of this room air or useful air current, which is cooled during the passage in the ducts formed by the plate or the toil 16, is returned as a cooling air current in counterflow to the useful air current through the ducts 18, where the useful air is moistened by the water supplied from the upper part of the apparatus through jets 24, whereunder the earlier described evaporative cooling of the useful air takes place. The outlet from the cooling air ducts 18, which in Figs. 1, 3 and 6 are denoted 26, is connected to the exhaust air outlet of the space, usually a valve connected to the central exhaust system. The moist cooling air current which is a part of the room air, is removed in this way from the space.

Fig. 2 shows how the main part of the useful air current leaves the ducts 16 a cooled air to flow out into the space, while a partial current is turned and enters the ducts 18 as the cooling air current as described.

As illustrated in Figs. 1, 3 and 6 the plates 11-15 are preferably made rectangular, but at one vertical end, the left one in the figures, provided with a connection part preferably shaped as an unequal sided triangle, where the shorter side 26 constitutes the outlet from the second duct system 18 while the longer side 28 constitutes the inlet to the duct system 16. The length of the sides can be varied relatively

to one another depending on the magnitude of the air currents. In order to seal the duct system 18 from the duct system 16 at this triangular end, a sealing strip 30 is disposed between the plates 11-15 contiguous to the ducts 18, as is illustrated in Fig. 6. In this figure which shows the plate 11 or 15 viewed from the inside of a duct 18, there can be seen also the spacers 32 which determine the width of the ducts 18. It is also evident that the sealing strip 30 forms a spacer too. The more or less dot-shaped spacers 32 may also be replaced by corrugated strips at the upper and lower edges of the plate 12, 14 as well as the right hand end thereof. The corrugations in the strips then follow the respective directions of water or the cooling air current.

Fig. 3 denotes the cooling air current in a duct 18, wherefrom it becomes clear that the cooling air current flows from the right side of the body to the outlet 26. When the other duct system includes ducts 18 extending over the entire surface of the sheet and which are not divided by intermediate walls or corrugations, it may happen that the cooling air current at its top has a tendency to deviate upwards where the ducts are open towards the water supply jets 24, such as indicated by the dashed line in Fig. 3. Different measures may be taken to reduce this deviation tendency, e.g. intermediate walls 34 can be arranged between the jets 24, as is shown in Fig. 4. From Fig. 3 it is also evident that the body at its bottom is provided with a collection trough 36 for excess water. If so desired, recirculation of water from the trough 36 to the jets 24 can be arranged. Also at the trough 36 intermediate walls 35 can be arranged to prevent downwards directed deviation of the air, which would deteriorate the heat exchange in this part of the body 10.

It is thus of great importance for the desired cooling effect to be achieved that the cooling air current is retained within the duct system 18. A leakage therefrom due to portions of the cooling air passing by outside the active heat transferring surface has a doubly negative effect on the cooling. This cooling is namely dependent on both amount and temperature of the cooling air. If the amount decreases due to bypassing, this decreased amount of air has a reduced capacity for attracting energy from the air current in the ducts 16, which results in that the air current leaves the ducts 16 at an increased temperature. This raised temperature results in that the cooling air current also gets an increased temperature, which further reduces its capacity to attract energy. In this way the negative effects on cooling thus combine very deleteriously, and it is against this background it is so important to prevent the criticized bypassing.

By the invention, the drawbacks described in the introductory part as met in the conditioning of the air in ventilation systems having intake and exhaust air ducts, such as large air volumes, insulation of the ducts and increased consumption of energy, are avoided by incorporating the described apparatus, so that the room air is utilized for the useful and the cooling air currents. When, for example, cooling three parts of the room air, causing two parts to return as useful air and causing one part of the room air to escape as exhaust air, one achieves that there is sufficiently much cooled air for delivering the chilliness simultaneously with retaining the exhaust air and the intake air at their volumes determined by hygienic reasons. Furthermore, one need not to make any interference in the air system in

the room, which it is indispensable to make in most cases with previously known systems of the kind described hereinbefore.

The apparatus is to be connected to the exhaust air system in such a manner as to disturb the flow of the exhaust air system as slightly as possible when the apparatus is connected or disconnected. Most preferably this should be done without using any throttle valves. The design according to Fig. 1 complies with this demand.

When chilliness is not required, the fan 22 is stopped, the exhaust air system then attracting all air from the room via the openings to the ducts 18 on the right-hand side of the apparatus body. At the same time the supply of water to this second duct system 18 is stopped also. When the fan runs it is instead the cooled air which is sucked in through the same openings.

Thus, the pressure image is scarcely changed at all at the inlet to the wet ducts 18 irrespective of whether the fan is running or standing still. Furthermore, it is possible to dimension the apparatus so that the fall of pressure on the wet side becomes low. When attaching it to an existing system, there will not be any appreciable disturbance of the exhaust air flow by the little excess of pressure fall introduced into the system.

The described system is utilized suitably where there is not too moist in the room and in the climate outside the building. In e.g. our Swedish climate the system will work in most cases of load, and there are large parts of the world outside Sweden where it is possible

to solve the problem of air conditioning with this type of plant. There exists also a possibility of extending the geographic territory where the principle here in consideration can be adapted, namely where the climate is moist. By centrally drying the intake air it is possible to lower the moisture content in the interior of the room or space so that the cooling principle works. It is not necessary to change the quantity of intake air or to insulate some ducts, but only in one or other way to dry by means of cooling condensation with subsequent heating or with a sorption dryer.

Some more energy is consumed, but the sacrifice of energy will be less than in many conventional systems. In any case it is possible to equip an already existing ventilation system afterwards in this way without reconstructing the whole building.

Even if the invention has been described with reference to counter-current between the flow of usefule air in the ducts 16 and the flow of cooling air in the ducts 18, one can imagine also to conduct the cooling air flow in cross-current to the useful air flow. In this case the cooling air should be fed into the ducts 18 at the top side of the body and flow downwards trough the body in parallel flow to the water supply to become discharged at the underside of the body and there delivered into the exhaust air ducts in the ventilation system.

It is obvious that the invention is not limited to the illustrated and described embodiments but can be varied in the widest sense within the scope of the basic idea thereof.

C L A I M S

1. Method for conditioning or cooling of the air in a room, wherein a contact body is used which is made up of layers and divided into two duct systems, of which one duct system is passed through by a cooling air flow which produces the cooling of the firstmentioned useful air current, the cooling effect being produced to a substantial part by evaporation of water into the cooling air in the second duct system, c h a r a c t e r i z e d in that the useful air current is taken from the room and that the cooling of the same is performed branching off a part of the useful air current after its passage through the ducts of the first duct system and returned through the ducts of the second duct system and serves as cooling air current, whereafter this part of the room air is diverted as exhaust air into the atmosphere outside the room.

2. Method as claimed in claim 1, c h a r a c t e r - i z e d in that that part of the room air which is used as cooling air current, amounts to 10-50% of the useful air current which is cooled.

3. Method as claimed in claim 1 or 2, c h a r a c t- e r i z e d in that the useful air current is conducted mainly horizontally through the contact body and that water is supplied vertically at the top side of the contact body to the second duct system.

4. Method as claimed in any of the claims 1-3, c h a r a c t e r i z e d in that the useful air current and the cooling air current are conducted in counter-current to each other.

5. Method as claimed in any of the claims 1-3, c h a r a c t e r i z e d in that the useful air current is conducted in cross-current to the cooling air current.

6. Method as claimed in any of the claims 1-5, c h a r a c t e r i z e d in that a pressure fan is used for causing the useful air current to enter into the first duct system, the fan and the water supply to the contact body being shut off when the room shall not be cooled.

7. Apparatus for carrying out the method as claimed in any of the claims 1-6 for indirect, evaporating cooling of the air in a room and comprising a contact body made up of layers with between the layers formed ducts which are divided into two duct systems separated from each other and of which one system is passed through by the useful air current which is constituted by the room air and the other one by the cooling air current which effects the cooling of the mentioned useful air current, said cooling to a substantial extent being produced by the evaporation of water into the cooling air in the second duct system, c h a r a c t e r i z e d in that the contact body comprises substantially flat plates disposed in parallel adjacent one another, between certain of the plates flange-shaped members being arranged, which members determine the spacing between the plates and form substantially horizontally extending ducts in the first duct system, spacers being inserted between the other plates, which spacers form the second duct system for the cooling air current between the plates as well as permit that water is supplied vertically to said second duct system from the top side of the body.

8. Apparatus as claimed in claim 7, c h a r a c t e r - i z e d in that the panels are rectangular and that the one vertical side is shaped as a triangle, the base of said triangle forming said vertical side and the two other sides of the triangle defining inlets to the first duct system and outlets from the second duct system.

9. Apparatus as claimed in claim 8, c h a r a c t e r - i z e d in that that part of the triangle-shaped portion of the panel which constitutes inlet into the first duct system is designed with substantially lower flow resistance than the rest of the duct system.

10. Apparatus as claimed in any of the claims 7-9, c h a r a c t e r i z e d in that the spacers are arranged in a dot-shaped manner between the intrinsically stiff panels.

11. Apparatus as claimed in any of the claims 7-10, c h a r a c t e r i z e d in that the two ducts systems extend substantially horizontally in the body and that the inlet into the first system and the outlet from the second system are arranged separately from one another but at the same end of the body, whereas the two duct systems debouch jointly at the opposed end of the body so that the air to the second duct system is branched off as a part of that air which has passed through the first system.

Fig. 1

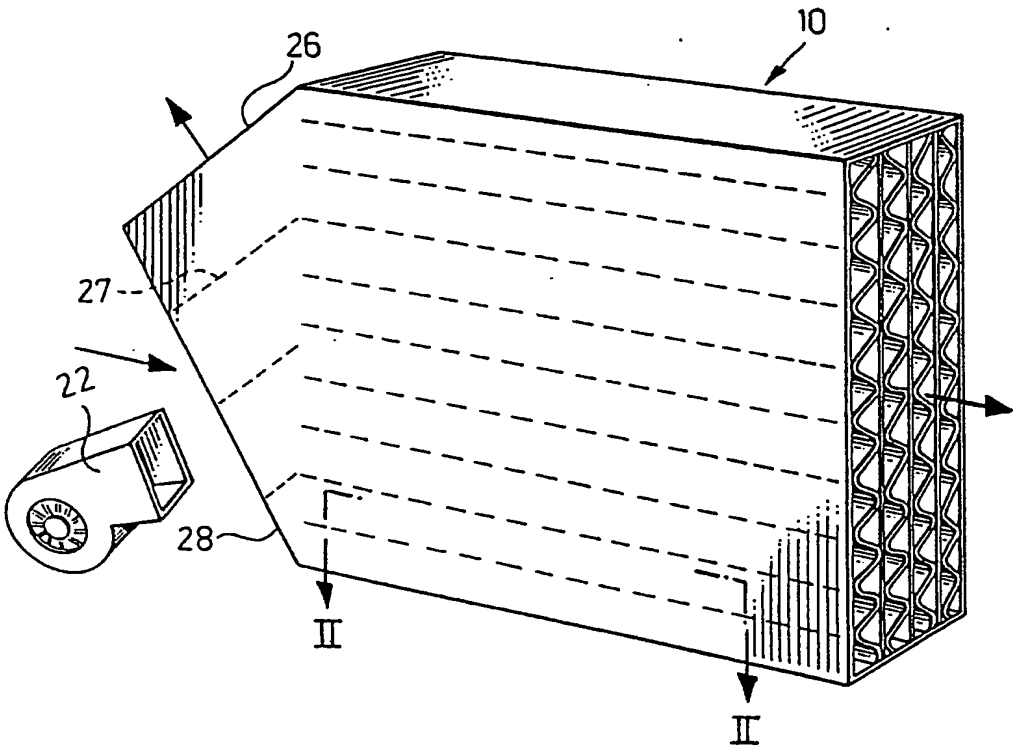


Fig. 2

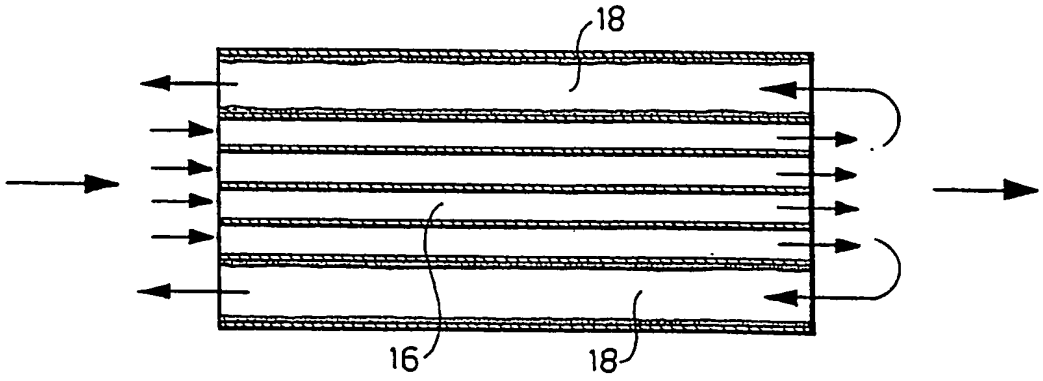


Fig. 3

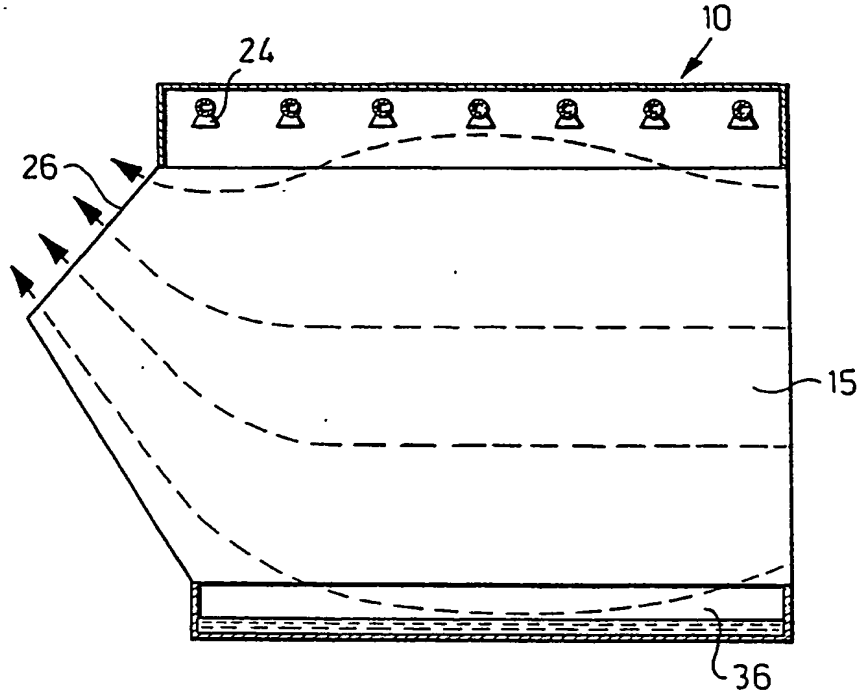


Fig. 4

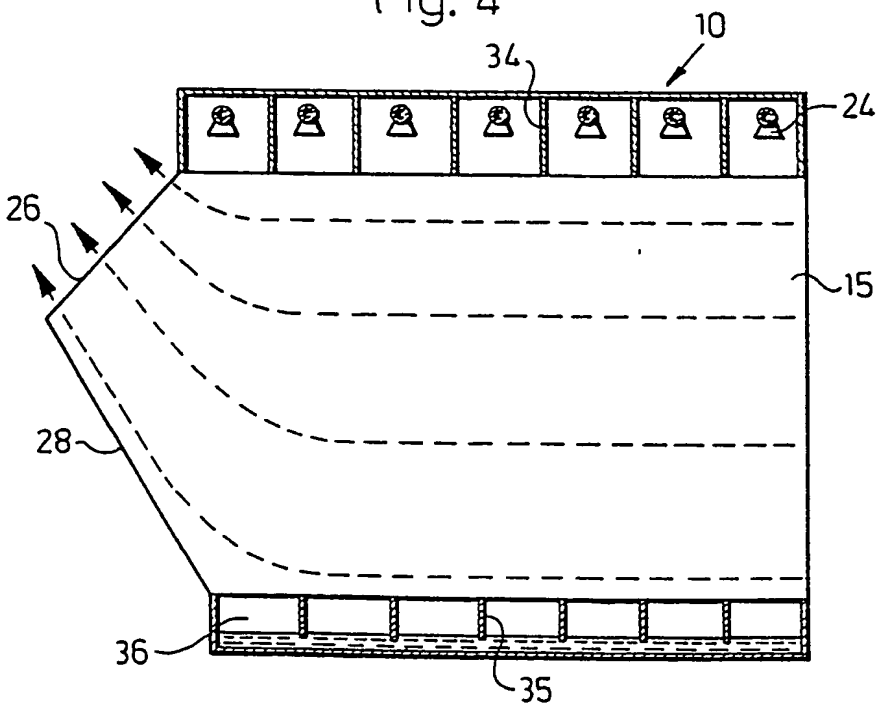


Fig.5

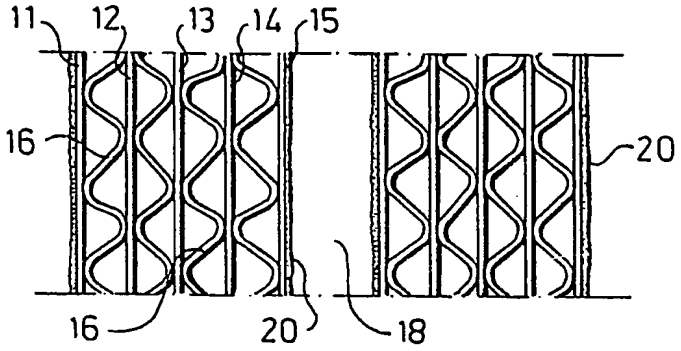
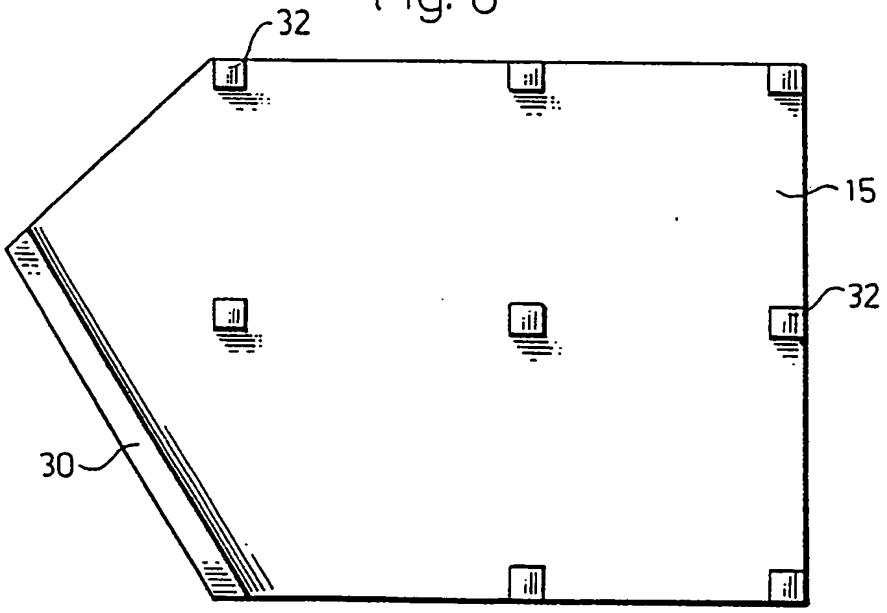


Fig. 6



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE86/00368

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [8]

According to International Patent Classification (IPC) or to both National Classification and IPC 4

F 24 F 5/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	F 24 F 3/00, /14, /147, 5/00; F 25 D 7/00, 9/00; F 28 C 1/00-/06; 3/00, /02, /06, /08; F 28 F 25/00
Nat Cl	36c:7; 36d:1/10, /14, /52, /54, /56; .../...

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
P	SE, A, 8502692-0 (B V VAPOCHILL) 5 December 1985	1, 3, 5, 7, 10
Y	SE, B, 383 777 (AB CARL MUNTERS) 29 March 1976 corresponds to SE, A, 7310061 20 January 1975 & BE, 817796 FR, 2238121 DE, 2432308 AU, 71301/74 US, 4002040 GB, 1471610 CH, 596510 CH, 1044594 JP, 50049752	1, 3, 4, 5, 6, 7, 11
Y	Derwent's abstract No 83-793201/42, SU, A, 979 796 (Odess eng cons inst) 1982-12-17.	4, 11
Y	Derwent's abstract No 85-048878/08, SU, A, 1 103 053 (As tadz solntse res) 1984-07-15. .../...	4, 11

[10] Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1986-11-07	1986 -11- 17
International Searching Authority	**Signature of Authorized Officer**
Swedish Patent Office	Nils Åke Axelsson

L.E

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

II Fields Searched (cont).

US Cl 62:121, 309, 310, 314, 315;
165:2, 3, 19-21, 50, 60, 63, 66, 164-167;
261:75, 158-161

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers....., because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers....., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	US, A, 3 305 010 (R L CAMPBELL, G P DEETER) 21 February 1967	8